equal to the force N. But the inertia coefficient m is not a constant, but a function of velocity, "precisely as the familiar transversal mass of an electron."

He proceeds to investigate a formula that will account for the whole of Mercury's excess. Putting β=velocity of planet/velocity of light, and $\gamma=(1-\beta^2)^{-\frac{1}{2}}$, *i.e.* $1+\frac{1}{2}\beta^2$, then if M_0, m_0 be rest-masses of sun and planet, $m=m_0\gamma$. Assuming for the law of force $M_0 m_0 \gamma^{n-1}/r^2$, or its equivalent, $M_0 m \gamma^{n-2}/r^2$, where n is an arbitrary constant, he shows that the value 6 for n gives the centennial excess 43″ for Mercury and 8·6″ for Venus. "Why n is just 6 I do not know. But as little do we know why the exponent of r is -2."

ANOMALOUS DISPERSION.—By the use of the electric furnace Dr. A. S. King has found it possible to investigate the anomalous dispersion of the more refractory elements, under conditions which can be kept well controlled (*Astrophysical Journal*, vol. xlv., p. 254). The amount of anomalous dispersion shown by a line is proportional to its intensity in absorption, provided the vapour absorbing the line in question has the requisite non-uniform distribution equivalent to a prism. Lines which show a strong anomalous dispersion at a low temperature frequently show refraction in the opposite direction when the temperature is raised, thus indicating that the vapour prism absorbing such lines has been inverted. When two elements with different melting points are mixed, the direct and inverted effects may occur simultaneously, and a similar result has been found in the case of a single element for lines which require different temperatures for their production. Thus the blue line of calcium, λ 4227, may show the inverted effect, while at the same time the H and K lines show anomalous dispersion of the regular type. Each element thus has the capacity to give its own anomalous dispersion independently of other vapours which may be present, and a similar relation holds for particles of the same element emitting lines of different character. No evidence was found for mutual repulsion of close lines, one of which is in a condition to show large anomalous dispersion, and it would appear that the theoretical effect is too small to be detected by laboratory methods now available.

THE VARIABLE STAR *u* HERCULIS.—The conclusion that *u* Herculis is a variable of the β Lyræ type has been verified by W. Dziewulski, from observations made with a 4-in. comet-seeker at the Cracow Observatory (*Astronomische Nachrichten*, No. 4887). The observations indicate no correction to Hertzsprung's period of 2·051027 days. At principal and secondary minima the magnitudes are 5·51 and 5·17 respectively, while at the two maxima the magnitude is 5·01. The light-curve is slightly unsymmetrical.

THE FUTURE OF THE DISABLED.

THE problem of the disabled sailor and soldier is one of great magnitude. Fortunately, it is only a small minority of the sick and wounded that is doomed to total disablement and to become the helpless subjects of their neighbours' loving care for the rest of their lives. For the majority hope and anticipation remain in varying degree—hope of restoration, more or less complete, of the maimed body, and anticipation of a life of some amount of independence and usefulness in the future. The latter is to be sought in a course of adequate treatment and training which is now receiving careful attention.

The disabled are frequently under the mistaken apprehension that if they again become industrially efficient the pensions awarded to them as disabled men will be taken away or diminished. This idea is quite devoid of foundation; the pension, once awarded, can never be withdrawn or reduced.

Those who wish to help the disabled man can often best aid him by enabling him to obtain a clear idea of the various openings that lie before him. The organisation now in being for training the disabled man, for opening to him a satisfactory place in life, and incidentally for carrying his cure a stage further, is not yet complete, but for some time past it has been far more effective than is commonly known, and it is steadily growing.

In a new periodical entitled *Recalled to Life*,[1] the first number of which was issued in June, the problem of the disabled is, and will be, considered in all its aspects.

Among the contents there is a memorandum prepared by Sir Alfred Keogh, Director-General, Army Medical Service, on the treatment of the disabled. Col. Sir Robert Jones discusses orthopædic surgery in its relation to war. With regard to treatment, it is important to note that when surgery, massage, exercises, electrical treatment, and other curative measures have carried the cure so far as it will go, manual training will frequently carry it a stage further, and when the patient finds that he is really capable of doing some useful and remunerative work he acquires a new zest for life.

The after-care of the blind is provided for at St. Dunstan's under the guidance of Sir Arthur Pearson. In the education of the blind two cardinal factors have to be appreciated. First of all, those who have lost their sight must be *taught* to be blind, and, having realised their state, they must be re-educated and trained. The principal occupations and industries taught at St. Dunstan's are the reading of Braille, typewriting, cobbling, mat-making, basket-making, and joinery. The men acquire these industries in a quarter the time that is generally supposed to be necessary to teach a blinded man a trade. The explanation of this speedy training is to be sought, first, in the employment of blind teachers, and, secondly, in the adoption of short working hours (9.30 to 12 and 2.30 to 4.30). The whole outlook of a man becomes different when he finds himself in the hands of a teacher who labours under the same disability as himself. Working under the handicap of blindness imposes a mental strain very much greater than might be imagined, and the shortness of the working day, paradoxical as at first it may seem, is one of the principal reasons for the remarkable speed with which handicrafts are acquired at St. Dunstan's. The subject of pensions is dealt with very fully in another article by Capt. Basil Williams, and other important papers and reports appear in this journal, which is illustrated by many plates showing disabled men practising the handicrafts they have learnt. Finally, a tabulated list is given of training classes for the disabled.

We commend *Recalled to Life* to the serious attention of all those who are aiding in the great work of succouring the disabled and of helping them to become again useful members of the State.

REFRACTORIES USED IN THE IRON AND STEEL INDUSTRY.

ALTHOUGH the Faraday Society held a general discussion on refractories so recently as November last, prominence was given to this matter in so far as it affects the requirements of the iron and steel industry at the May meeting of the Iron and Steel Institute. The subject was very ably introduced by Mr. Cosmo

[1] Editor: Lord Charnwood. Assistant Editor: Everard Cotes. (London John Bale, Sons, and Danielsson, Ltd.) Price 2s. net.

Johns, the furnace manager of Vickers, Ltd., and took the form of a compact statement of the properties of the refractories in general use and the urgent need for systematic research work along certain lines.

In any given metallurgical process the ideal refractory must be infusible and non-volatile; its volume must not vary during the temperature fluctuations that occur; it must be chemically inert; it must have sufficient structural strength and be a non-conductor of heat. No such substance is known. Whether any such material can be prepared only the future will show. Up to the present the refractories actually used are simply the best approximations to the above ideal, which have been reached almost entirely by experience gained by empirical trials spread over a century or more. As Mr. Johns observes:—"The methods employed to-day represent the survival of the fittest by the searching test of commercial success, but it by no means follows that they represent the best obtainable"; and, further:—"The art has been so long in front of the science of the refractory industry that the most urgent need at the present is for an expression in terms of scientific precision of the most successful practice in manufacturing the refractory product and of the physico-chemical changes which take place when they are used."

As regards the materials available, leaving aside carbon and its compounds with silicon, which have only a limited application, they are chiefly the oxides, silica, alumina, lime, magnesia, and chromium oxide, or compounds of these with oxides of iron, sodium and potassium, and traces of other substances, regarded as impurities, some of which may act as catalysts. The raw materials for coke-oven bricks, blast-furnace bricks, and casting ladle nozzles are the fireclays, most of which were obtained from home sources before the war. Again, quartzite, the raw material of silica bricks, used in acid open-hearth furnace construction, is entirely derived from home supplies. On the other hand, magnesite, the raw material of basic refractories used in basic open-hearth and electric furnace construction, is nearly all imported, either in the raw or calcined state. Chromite, the raw material of bricks used where a neutral refractory is required, which will not have a reducing action such as the carbon refractories exert, has also to be obtained from abroad. The materials available are therefore strictly limited, and they never occur in a state of purity in Nature. Their manufacture into finished refractories involves a succession of processes which vary according to the purpose for which they are intended, and the final product is always a mineral aggregate, often of great complexity. In consequence of this the refractory does not possess a melting point, but rather a softening range spread over a considerable temperature interval, which results finally in the material failing to perform its functions. It is essential that any refractory should be "burnt" at a temperature somewhat higher than it will be called upon to endure in practice; otherwise serious difficulties arising from volume changes, especially shrinkages, will be encountered.

Texture and porosity determine very largely the suitability or otherwise of refractories for particular purposes. The relative size of the grains, and the extent of the surface exposed by the more resistant constituents to the others used as a bond or matrix, are most important factors in contributing to the ability of the material to perform useful service. Another point of importance is the influence of mass in promoting or retarding inversions. Some inversions occur almost instantaneously once the critical temperature has been reached, but with others marked hysteresis occurs. Porosity must always occur when the refractory is composed of more than one constituent, and where their chief volume changes are dissimilar, or occur at different temperatures. Little is known of the effect of porosity on properties, but it is obvious that it permits the deposition of extraneous material in the interior of the bricks and renders them permeable to gases.

Both tenacity and compressive strength are important properties of refractories at high temperatures. Abrasion is caused by the movement of solid substances while in contact with their heated surfaces; erosion is due to the passage of dust-laden gases at high velocities. Almost nothing is known as to the conditions which may be expected to retard abrasion and erosion, and in what way they are related to the mechanical properties of the materials. There is accordingly urgent need for the accurate determination of tenacity and compressive strength, over wide ranges of temperature, of the chief refractories under both oxidising and reducing conditions. Not less important is the property of resistance to corrosion caused either by slags or gases. The effects of acid slags on basic refractories, and of basic slags on acid refractories, are well known. Less familiar, except to experts, are the instances of gas corrosion of the silica bricks in the gas ports and uptakes of open-hearth furnaces due to the alternating passage of oxidising and reducing gases with the resulting formation of fusible silicates.

It is satisfactory to be able to record that the Geological Survey is preparing a memoir of the mineral resources of this country, and is dealing specially with refractories. Mr. Johns points out that the concentration and purification of these, their proximate and ultimate analysis, their mineralogical description, and their thermal analysis are all matters requiring scientific investigation. Pioneer work has already been carried out under Dr. Mellor at the Pottery Laboratory, Stoke-on-Trent. Researches are also in contemplation, or have been initiated, at various universities and technical institutions in the country.

H. C. H. C.

THE COMPLEXITY OF THE CHEMICAL ELEMENTS.[1]

THE elements of the chemist are now known to be complex in three different senses. In the first sense the complexity is one that concerns the general nature of matter, and therefore of all the elements in common to a greater or less degree. It follows from the relations between matter and electricity which have developed gradually during the past century as the result of experiments made and theories born within the four walls of this institution. Associated initially with the names of Davy and Faraday, they have only in these days come to full fruition as the result of the very brilliant elucidation of the real nature of electricity by your distinguished professor of physics, Sir Joseph Thomson. Such an advance, developing slowly and fitfully with long intervals of apparent stagnation, needs to be reviewed from generation to generation, disentangled from the undergrowth that obscures it, and its clear conclusions driven home. This complexity of the chemical elements is a consequence of the condition that neither free electricity nor free matter can be studied alone, except in very special phenomena. Our experimental knowledge of matter in quantity is necessarily confined to the complex of matter and electricity, which constitutes the material world. This applies even to the "free" elements of the chemist, which in reality are no more free then than they are in their compounds. The difference is

[1] Discourse delivered at the Royal Institution on Friday, May 18, by Prof. Frederick Soddy, F.R.S.